PATENT SPECIFICATION 768,535

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COMPLETE SPECIFICATION

Improvements in and relating to glow discharge tubes

We, SOCIÉTÉ TRIFLUX, of 11 rue Berton, Marseilles, (Bouches du Rhône), France a French Body Corporate, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to fluorescent or glow disharge tubes and provides improved means for controlling them, as well as advertising and display signs or like systems comprising a plurality of such devices. More particularly, the invention relates to means for controlling one or more glow discharge tubes so as to obtain a gradual increase in the illumination thereof from zero to a maximum, the tubes being of the type in which the discharge is made progressive from one end to the other of the tube, or from both ends towards the middle of the tube, by application to the latter of a high-frequency voltage of variable amplitude.

The main object of the invention is to provide improved means for controlling the discharge intensity in a glow discharge tube or system of tubes.

Another object is to provide such systems which are operated in a new and improved manner for producing a successive and gradual illumination of all the tubes comprising the system.

Further objects include the provision of such systems, which operate more efficiently, reliably and cheaply than heretofore and which utilize radio-frequency generating means; the provision of such systems which utilize radio-frequency generating means for supplying the tube or tubes during the gradually increasing illumination stage of the operation thereof, and a steady alternating voltage source, such as an alternating current network, during the steady illumination stage of said operation, and the provision of such systems which will not be a source of serious radio interference.

Various systems have been proposed for controlling a glow discharge tube so as to produce a gradual increase in the brightness of the discharge from zero to a maximum intensity. Such a result can, broadly, be obtained by applying to one electrode of a glow discharge tube a variable-amplitude high-frequency voltage, while the other electrode of the tube is held at or near zero potential, so that the discharge will gradually progress from the end of the tube containing the first electrode towards the opposite end. In practice, however, none of the systems previously put forward for carrying out this idea have met with any commercial success, their failure being due to various reasons inherent in the design and operation of such proposed control systems.

In the previously suggested systems there was provided between the high-frequency generator and the tube electrodes, an energy-transmission line inductively coupled at one end with the output of the oscillation generator and at its other end with an input circuit connected across the terminals of the tube. Since the impedance of the line must be held to a low value, and the voltage at the input end of the line should be low, whereas the voltage at the output end should be high, the electrical efficiency of the system was necessarily poor. Moreover, owing to the presence of two inductive couplings in cascade relation, it was practically very difficult to obtain a correct loading of the generator.

According to the present invention, there is provided between the high-frequency oscillation generator and the glow discharge tube an energy-transmission line which is coupled with the output of said generator and is connected across the terminals of the tube, said line containing a high-impedance inductance element in series with the tube input, and a capacitance in parallel across the tube. It has been found that such an arrangement makes it possible to produce

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a perfectly gradual illumination over a tube several yards long.

It has been found that it is particularly advantageous to use radio-frequency oscillations of the order of 100 kilocycles per second. The use of such frequencies is desirable in the first place because it is remote from the broadcasting frequency wave-lengths. Moreover, as will more fully be described hereinafter, high-capacity values may then be used for the capacitance connected across the tube terminals, in order to obtain resonance for the input circuit while maintaining a high L/C ratio. The value of said capacitance may then be selected so large as to dwarf any stray capacitance present in the tube and the associated circuit. This makes it possible to construct glow system control apparatus which will operate satisfactorily under all conditions.

According to another feature of the invention, the impedance value of the inductance element in the input circuit is substantially equal to that of the capacitance for the resonant condition, in which the input frequency equals the natural frequency of the input circuit, at which frequency the tube is fully illuminated.

Further, means are provided for gradually illuminating all the tubes in a plurality of tubes in succession, through the use of a cam-operated switching arrangement more fully described hereinafter, whereby on ignition of each particular tube, the tube is supplied from a steady alternating current source, after which the next tube in the plurality is ignited and supplied, and so on.

The invention is hereinafter described with reference to the accompanying drawings, in which:—

Fig. 1 is a simplified diagram illustrating an improved glow discharge tube control circuit according to one embodiment of the invention.

Fig. 2 illustrates a modified control circuit.

Fig. 3 shows a further modification.

Fig. 4 illustrates a form of embodiment of the high-frequency oscillation generator, connected in a circuit similar to Fig. 1.

Fig. 5 is a schematic illustration of a variable condenser arrangement and cam-operated switch means associated therewith, for automatically varying the frequency of the input oscillations to successive tubes of a plurality according to a predetermined sequence.

Fig. 6 is a partial diagram illustrating means for controlling a plurality of tubes to be operated in succession.

Fig. 7 shows a modified control system for a plurality of tubes.

Fig. 8 illustrates a circuit whereby a common high-frequency generator may be utilized both to ignite a tube gradually and to maintain the energization thereof at a steady value.

Referring first to the circuit diagram of Fig. 1, a high-frequency oscillation generator 1 has its output connected with an inductance 2. Inductively coupled with the inductance 2 is a winding 3 connected in the circuit 4 serving to transmit the energy from the high-frequency generator 1 to a glow discharge tube 5. Connected in this circuit, in series with the secondary winding 3, is an inductance 6, and a capacitance 7 is connected in parallel across the terminals of the tube 5. As shown, one end of the winding 3 and one end of the tube 5 are earthed to provide a return connection for the circuit.

It will be noted that the circuit just described involves only a single coupling, viz. the inductive coupling between the windings 2 and 3. Moreover, the arrangement of the inductance element 6 and capacitance 7 makes it possible to impart to the circuit the requisite characteristics for obtaining a very smooth and gradual illumination of the tube as the energizing voltage applied to the tube is increased.

With the glow tube 5 cut off, the high-frequency voltage is applied to the upper terminal *5a* thereof and the amplitude of this input voltage is gradually increased in a manner to be later described. As the input voltage is increased, the tube lights up gradually along its length until it has become fully illuminated throughout.

Instead of the circuit shown in Fig. 1, alternative circuits may be used as illustrated by way of example in Fig. 2 and in Fig. 3. In the first modification, Fig. 2, the coupling of the input energy is produced by means of an auto-transformer 8; while in the second modification, Fig. 3, a capacitative coupling is used, by means of condensers 9. In other respects, both the circuits of Figs. 2 and 3 are similar to the embodiment disclosed in connection with Fig. 1.

Any suitable type of oscillator may be utilized in accordance with the invention, for generating the variable-amplitude voltage for the glow-discharge tube. Fig. 4 illustrates one particularly desirable type of oscillator circuit for the purposes of the invention. The circuit includes an oscillator stage comprising a conventional triode 10 and a resonant circuit consisting of an inductance 12 and condenser *11a* in parallel connected between the grid and anode of the triode. A mid-point of the inductance 12 is connected to the cathode and to earth. Connected between the anode and earth is a variable condenser 11 serving to adjust the frequency of the oscillator. The output winding or inductance 12 is inductively coupled with a winding 13 inserted in series with the control grid of an output amplifier tube 14, the anode of which has connected

with it a parallel resonant circuit including a condenser in parallel with an inductance 2, which serves as the primary winding likewise designated 2 in any one of Figs. 1, 2 and 3. The remainder of the circuit of Fig. 4 has been shown identical with the circuit of Fig. 1, but it will of course be understood that this part of the circuit may instead be made identical with Fig. 2 or with Fig. 3.

In operation, adjustment of the condenser 11 varies the frequency of the output produced by the oscillator 10 and hence varies the output frequency from the amplifier tube 14. As a result, there is applied across the terminals of the glow tube 5 a variable voltage which has a minimum amplitude when the over-all circuit is far from its resonant condition and which gradually increases in amplitude as the circuit approaches resonance.

Let f_o be the resonant frequency of the circuit comprising the inductance 3, line 4, inductance 6, condenser 7 and glow tube 5; this is the frequency value for which the glow tube 5 is fully illuminated. The resonant frequency f_o may be approached in either of two ways, i.e. starting from lower frequencies or starting from higher frequencies. In practice, it is desirable to start from the higher frequencies and to reduce the frequency until resonance has been reached. This procedure is preferable since on ignition of the tube its capacity rises due to the ionization of the gas therein; hence the quantity $1/(2\pi L C)$ diminishes; therefore by starting from frequencies above the resonant frequency, gradually reducing the frequency, the quantity just noted will be varied in the same sense as the frequency, so that a very gradual increase in illumination of the glow tube is obtained.

As previously stated herein, the oscillator may be used for gradually illuminating in succession a number of glow discharge tubes constituting, for example, an advertising sign or the like. Fig. 5 illustrates parts of a circuit arrangement suitable for such a purpose. As shown, the variable condenser 11 of Fig. 4 is herein replaced by two variable condensers in parallel, each diagrammatically indicated as comprising a fixed electrode 19, 20 respectively, and a rotatable electrode 15, 16 respectively; the remainder of the circuit for each of the glow tubes may be as shown in Fig. 4. The movable electrodes 15 and 16 of the two condensers are displaced 180° from each other and are secured on a common shaft 17 adapted to be rotated by an electric motor 18. The fixed electrodes 19 and 20 are connected to the respective fixed contacts of a reverser switch, the movable contact arm 21 of which is connected to the anode of the oscillator tube 10. The movable contact arm 21 is actuated between its two positions in engagement with the respective fixed contacts, by a cam device 22 driven from the motor 18 through a suitable transmission indicated in dotted lines.

In operation, the two variable condensers are made operative alternately, the adjustments being readily made in such manner that, as soon as one glow tube has become fully illuminated, this condition being reached when one of the condensers has attained its maximum capacity, the frequency is suddenly switched back to a value for which the said tube is cut off, owing to the fact that the first mentioned condenser is switched out of circuit by the action of the reverser switch; by the same action of the reverser switch, the other condenser, which at the time stands at its minimum capacitance value, is connected in circuit instead, and the other tube is gradually made to glow until it is fully illuminated, whereupon it is cut off and the cycle is repeated. It will be apparent that by the use of a suitable switch this arrangement can be used with any number of glow tubes, which can thus be made to light up gradually in succession, each tube being cut off as the next tube of the series starts to glow.

In order to maintain the discharge in the tube after it has been ignited, switching means may be used whereby a tube on being fully illuminated is thereafter supplied from a constant-frequency source, either at high-frequency or at industrial network frequency. Such a switching arrangement may be operated in synchronism with the switching arrangement described in the foregoing paragraphs, in such a way that on ignition of any tube the variable radio-frequency input is disconnected therefrom and the constant-frequency source is connected thereto instead. An example of one such arrangement is illustrated in Fig. 6.

A plurality of glow tubes, e.g. three as shown, are indicated at 5, 5′ and 5″, and may for example form parts of a shop sign, the tubes being so shaped and disposed as to form the letters of a name or the like. Each tube has one terminal earthed and the other terminal connected to the variable amplitude line 4 through a respective switch 23, 23′, 23″. Starting with the tubes cut off, a radio-frequency voltage is gradually applied to the terminal 5*a* of the first tube 5, and its amplitude is gradually increased in the manner indicated above. As the applied voltage increases, the tube 5 progressively becomes illuminated along its length until it glows throughout. At this time, the switch 23 disconnects the tube 5 from the variable-amplitude energizing source and connects the source instead to the line 4′ for energization of the next tube 5′ by way of a switch 23′; in turn the tube 5′ will be disconnected by the switch 23′ and the source connected to a third tube 5″ by way of a switch 23″, and so on.

Moreover, there is associated with each switch 23, 23′, 23″, a switch 24, 24′, 24″, so connected that whenever the first switch disconnects the related tube from the variable voltage source on the line 4, the second switch 24, 24′, 24″ associated therewith will connect the tube to a constant-amplitude supply source which will serve to maintain the discharge therein.

In the exemplary circuit illustrated in Fig. 6, the constant-amplitude supply is provided by a normal alternating current network operating for example at 50 cycles per second, through suitable transformers 25, 25′, 25″, of which the primary windings are fed from the network as indicated at *a, b, b′, b″*. Choke coils 26, 26′, 26″ are provided in the transformer output lines for blocking the high-frequency during the starting period of the respective tubes.

The associated switches 23-24, 23′-24′, 25″-25″, are preferably ganged and operated by cams driven from a motor such as the motor 18 (Fig. 5), the shape and setting of the cams being so predetermined as to cause them to perform the desired functions with the requisite timing, that is, successively to disconnect each tube when it has been ignited from the variable-amplitude high-frequency source, and connect it instead to the constant-amplitude industrial frequency source for maintaining the tube in ignited condition and simultaneously connecting the next tube to the variable-amplitude high-frequency source.

Fig. 7 illustrates a modified circuit wherein the discharge in the ignited tubes is maintained by energization from a constant-amplitude high-frequency source by way of the switches 24, 24′, 24″. In other respects this circuit operates in the same manner as described in connection with Fig. 6.

After all the tubes such as 5, 5′, 5″, etc., forming the electric shop sign or the like, have been ignited, they may be simultaneously extinguished and then the cycle may be recommenced by gradually re-igniting the first tube, and so on. The shaping and setting of the operating cams can readily be determined to produce the desired cut-off of all the tubes at the end of each cycle.

It should however be noted that the shaping of the cam contours must be determined with great precision in order to avoid having some of the tubes remain in ignited condition even for a short time after the remaining tubes have been cut off. Moreover, even where the cams are accurately formed and set originally, wear is apt to effect this condition after some time. Accordingly, a further arrangement may be provided in accordance with the invention to ensure the desired simultaneous cut-off of all the tubes at the end of each cycle.

This arrangement comprises a switch 27 (Fig. 6) operated for example by a motor driven cam, which will cut off the supply circuit to the screen grid 29 of the triode 14 (Fig. 4) as soon as the last glow tube of the series has become fully illuminated, and another cut-off switch 28 ganged with the cut-off switch 27, for simultaneously cutting off the constant-amplitude supply circuit.

As shown in Fig. 8, an oscillator 30 having a constant-amplitude high-frequency output (e.g. at 120 kilo-cycles per second), may be used to supply two circuits of the system. One circuit comprises a variable impedance 31 and the control grid of the amplifier stage tetrode 14, whereby said grid may be operated at a variable voltage so that a constant high-frequency input of variable-amplitude may be obtained for igniting the glow tubes. The other channel includes an amplifier 32 the output of which provides the constant-amplitude high-frequency input required to maintain the discharges in the tubes.

It will be understood that the invention is not to be limited to the forms of embodiment illustrated and described, but that various modifications may be made therein, particularly as to the type of oscillator used to generate the variable-amplitude, high-frequency voltage supplying the glow tube or tubes. Similarly, apparatus according to the invention may be applied in such a way as to produce a gradual illumination of a tube starting from both ends together and progressing towards the middle of the tube for which purpose an artificial zero point may be established intermediate the ends of the tube. The glow tubes used may be of the known type wherein internal electrodes are omitted and replaced by metallic elements or armatures located externally of the tubes.

What we claim is:—

1. Means for controlling glow discharge tubes of the type in which the discharge is made progressive by application to the tube of a high-frequency voltage of variable amplitude, characterized in that there is provided between the high-frequency oscillation generator and the glow discharge tube, an energy-transmission line which is coupled with the output of said generator and is connected across the terminals of the tube, said line containing a high-impedance inductance element in series with the tube input, and a capacitance in parallel across the tube.

2. Means according to claim 1, characterized in that the impendance value of the inductance element is substantially equal to that of the capacitance for the frequency at which the tube is fully illuminated.

3. Means according to claim 1, characterized in that the frequencies used are of the order of 100 kilocycles per second.

4. Means according to claim 1, characterized in that the oscillation generator is of

the variable-frequency type and that the circuit formed by the inductance element and the capacitance comes into resonance at a value of the frequency corresponding to the maximum voltage required for the full illumination of the tube.

5. Means according to claim 4, characterized in that the frequency of the oscillation generator is variable from a maximum value, greater than that corresponding to the start of the ignition of the tube, progressively down to the value corresponding to its full illumination.

6. Means according to claim 1, characterized in that a single oscillator is used for the successive ignition of two or more tubes.

7. Means according to claim 6, characterized in that the oscillator is provided, for the variation of its frequency, with two similar variable condensers displaced at 180° to one another, and acting in turn to allow, after the complete ignition of one tube, of changing over to ignition of the next tube without interruption.

8. Means according to claim 7, characterized in that the variable condensers are operated synchronously and that a switch connected to their operating means allows of causing them to act successively to cut off the connection with the oscillator of a tube which has just been ignited, and to contact the next tube with said oscillator.

9. Means according to claim 1, characterized in that it comprises a switching system allowing of substituting for the variable-amplitude high-frequency voltage, after ignition of a tube, a constant-amplitude high-frequency or industrial-frequency voltage for maintenance of the illumination.

10. Means according to claim 9, characterized in that it comprises a switch allowing, after full illumination of the tube or series of tubes, of ensuring the complete cut-off of the voltages for ignition and for maintenance of the tube or tubes.

11. Means according to claim 1, characterized in that it comprises a constant-amplitude high-frequency source from which there are produced both a variable-amplitude high-frequency voltage for igniting the tube or tubes, and a constant-amplitude high-frequency voltage for maintaining the tube discharge.

12. Advertising and display signs and the like including fluorescent tubes controlled by means according to claim 1.

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Fig.1

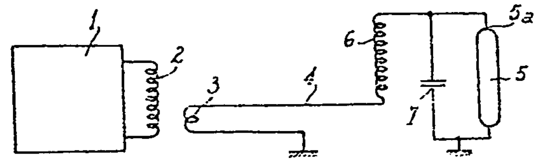


Fig.2

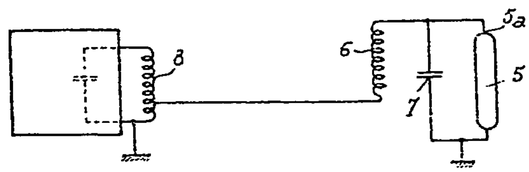


Fig.3

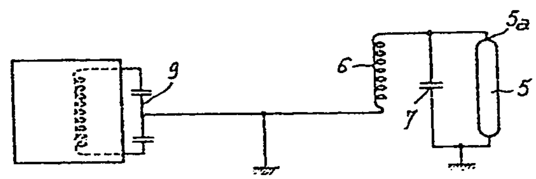


Fig.4

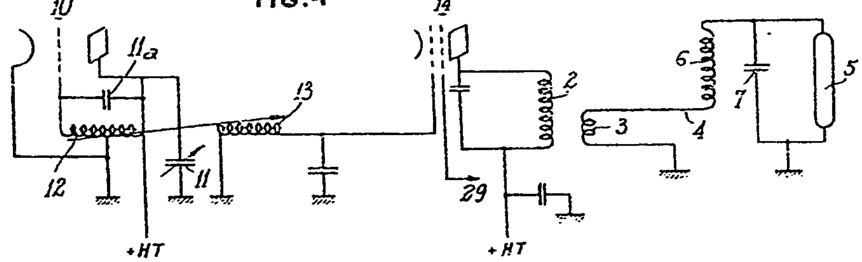
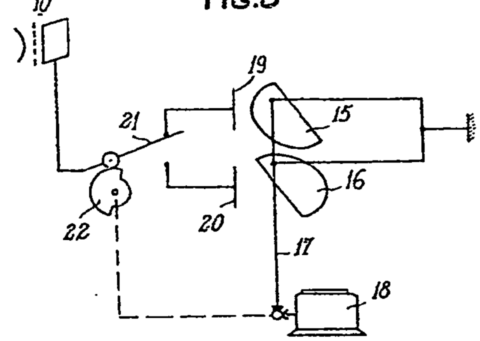


Fig.5



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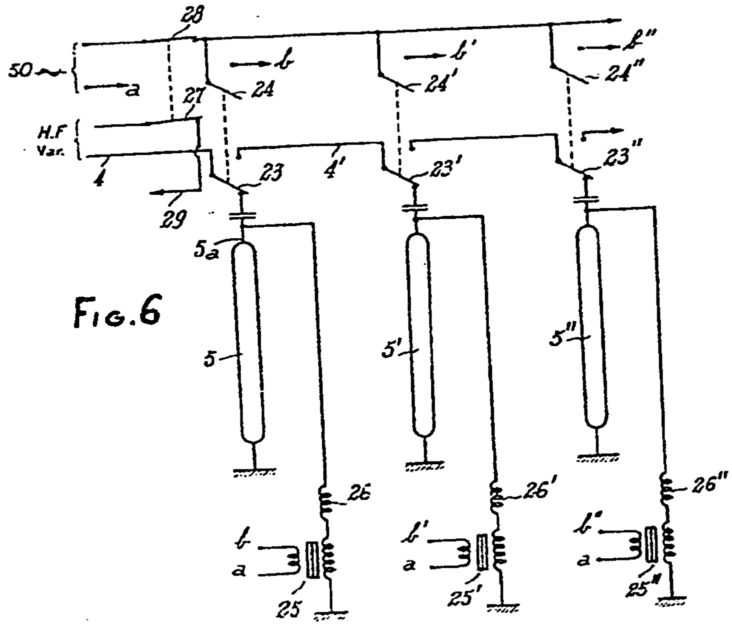

Fig. 6

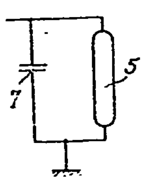

Fig. 7

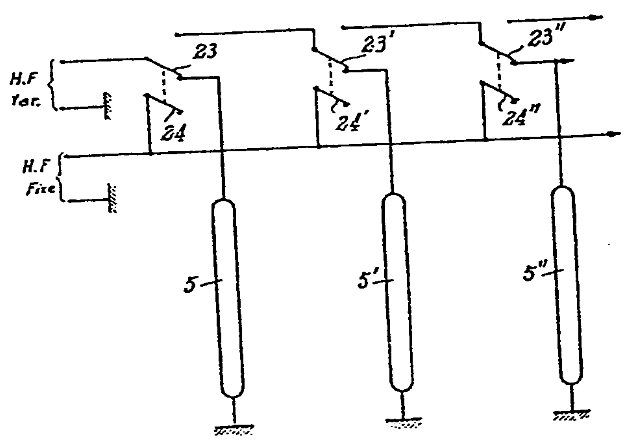

Fig. 8

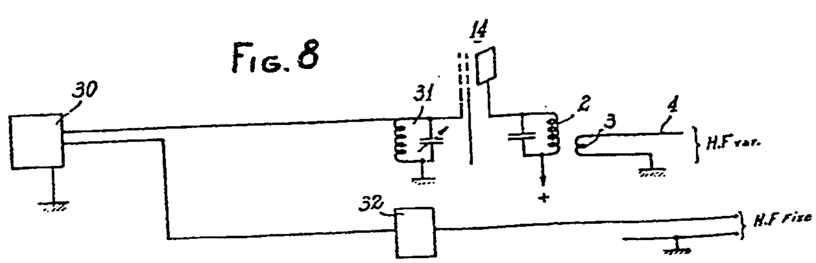

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Fig. 1

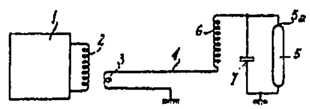

Fig. 2

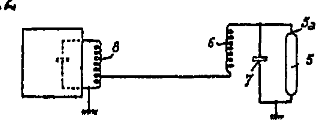

Fig. 3

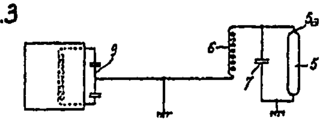

Fig. 4

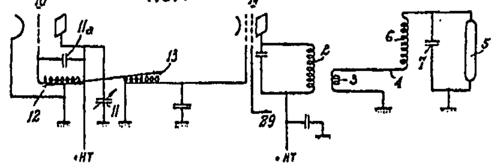

Fig. 5

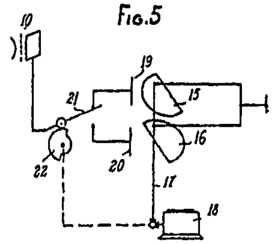

Fig. 6

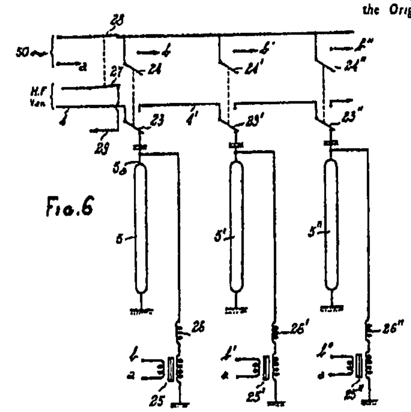

Fig. 7

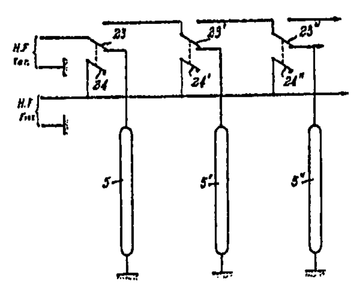

Fig. 8